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Research paper

Development of energy labels based on consumer perspective: Room air conditioners as a case study in Brunei Darussalam

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ABSTRACT

For the past years, Brunei Darussalam has seen an increase in its electricity consumption with an average annual rate of increase of 3% per annum from the year 2011 to 2015. Like other developing countries with tropical climates, electricity consumption from air conditioning systems contributes a big part to this electricity consumption. The Energy Department of the Prime Minister's Office is considering the implementation of energy label for air-conditioning system; to provide guideline for consumers to compare efficiencies of their systems, encourage manufacturers to improve the energy efficiency of their systems and ultimately, to reduce the overall energy consumption of the country. This paper proposes a suitable energy label for air conditioning system in this country based on an online survey. Data from the survey shall be analysed to come up with consumers' preferred energy label with suggestions used for its improvement. This label is also suitable for other electrical systems without major modification.

1. Introduction

There is a worrying trend in the amount of electricity consumption in Brunei Darussalam. It is recorded that the country consumed 3787 million KWh in the year 2015, giving an average annual consumption per population of 9079 KWh per capita and making it the highest consumer of electricity in South East Asian region (DEPD, 2015). The high consumption of electricity in Brunei may be attributed to the low subsidised price of electricity, the use of low energy efficient appliances as well the lack of knowledge of the general population on the principles of energy conservation (Ahmad and Othman, 2014).

Similar to other countries with hot and humid climate, the biggest contributor to these energy usage is from the use of air-conditioning system (Mahlia and Saidur, 2010a; Mahlia et al., 2010; Saidur et al., 2011; Shekarchian et al., 2011). It is reported that cooling represents 62% and 74% of energy consumption in residential and commercial buildings, respectively in Brunei Darussalam (EDPMO, 2013). This fact is further corroborated in reference (Ahmad and Othman, 2014) whereby it is reported that air-conditioning system contributes the most to the monthly consumption of electricity in the Bruneian households.

With these backdrops of increasing electricity consumptions and air-conditioning system as the largest guzzler of energy in residential and commercial buildings, it is essential for the country to develop effective policies and measures to curb the spiralling energy usage; particularly from air-conditioning system, if Brunei is to achieve its goal of a 45% energy intensity reduction by 2035. One of the policies and measures that may be adopted is by implementing energy efficiency standards and energy labels (Mahlia and Saidur, 2010b; Masjuki et al., 2001; Shi, 2014, 2015). Indeed, the Brunei government through the Energy Department at the Prime Minister Office (EDPMO) has expended effort and is currently developing its National Energy Efficiency Standards and Labelling Regulation.

Many countries in the world have successfully introduced energy efficiency standards and energy labels. It is reported that, in the year 2013, there exists 81 countries around the world with standards and labelling programs, with air-conditioning system being the second most commonly covered appliances with a country count of 73 countries implementing some kind of energy efficiency standards and labelling programs (Harrington and Brown, 2014). Of course, experiences and lesson learnt from these countries may be adopted in Brunei, however, some modifications may be required to make it more suitable to the socio-economic structure of the country.

Energy efficiency standards and energy labels usually come in pair (UNESCAP, 1999). Energy efficiency standards are procedures and regulations that prescribe the energy performance of manufactured electrical appliances, in our case, air conditioning systems, sometimes prohibiting the sale of systems that are less energy

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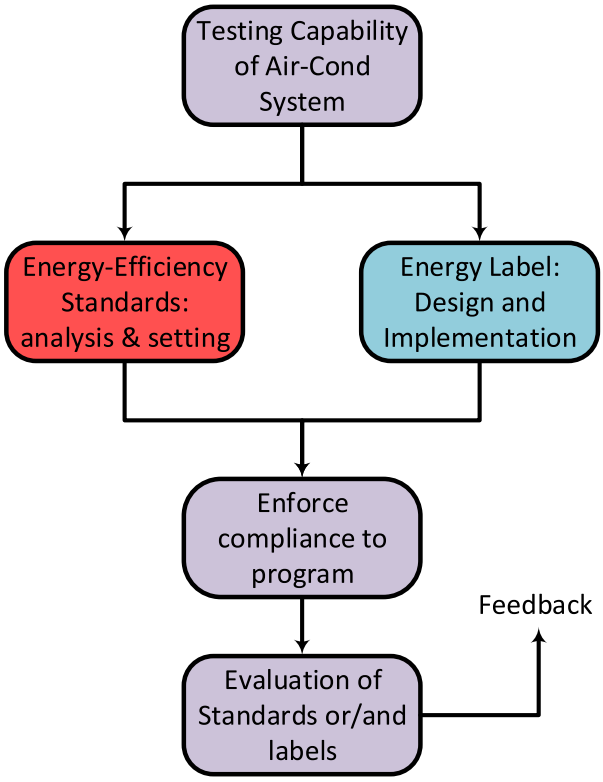

Fig. 1. Typical process of energy efficiency standards and energy labels program.

efficient than the minimum standard (Mahlia, 2004; Mahlia et al., 2002b,d, 2001; Wiel and JEM, 2001). This minimum standard provides the bottom threshold on efficiency level and as such, may halt the importation and sales of non-efficient air-conditioning systems into the Brunei economy. On the other hand, energy label is informative tool; describing the energy performance of air-conditioning systems, in order to enable consumers to compare the energy efficiencies of the different systems on a fair and equitable basis. It also has the effect of encouraging manufacturers to improve energy performance of their system (Mahlia et al., 2002c).

Hence, energy standards is more about technical settings of energy efficiency while energy labels attempt to stimulate consumers' awareness on the relative efficiencies and operating costs of appliances. Energy efficiency standards and energy labels can stand alone independently of the other; although it is commonly implemented to complement one another (UNESCAP, 1999), as part of energy efficiency standards and label program as shown in Fig. 1.

This paper specifically addresses the adoption of suitable Energy labels for air-conditioning system in Brunei. Generally, there exist two main types of energy labels (Wiel and JEM, 2001):

(1) Endorsement labels — labelling schemes identifying the most energy efficient models

(2) Comparative labels — labelling schemes with information on energy efficiency and cost, to allow consumers to compare different systems.

Within the context of Brunei, comparative energy label shall be adopted. This is because it is our aim to allow the consumers, themselves, to compare different appliances based on their energy efficiencies and costs; with due consideration on the different standards of living of the population in Brunei. Comparative energy label has also been adopted by several countries in the South East Asian region (Della Cava et al., 2000; Egan et al., 2000; Harrington and Damnics, 2004; Mahlia et al., 2002a,c, 2011; Masjuki et al., 2000a; Silitonga et al., 2011). Despite this, it is important for individual countries to develop their own energy label, which is suitable and appropriate depending on their local population; socio-demographic, culture and preferences. It must also be ensured that energy label provides understandable and sufficient information to help consumers make informed decisions.

The next section shall provide a general introduction to energy labels, specifically comparative energy labels for air-conditioning system. In Section 3, the paper discusses important aspects in the development of energy label and outlines the methodology that shall be used to propose an energy label for Brunei Darussalam. Analysis of the data and results shall be given in Sections 4 and 5. Sections 3–5 form the contributions of this paper. The last section concludes the paper.

2. Energy labels of air-conditioning system

Energy label should provide guidance to the consumers on energy efficiency of the air-conditioning system and more importantly, provide a basis for comparison with similar air-conditioning systems in terms of its energy efficiency or operating cost. The information must ultimately help the consumers in their decision-making process to choose the system with the lowest long-term cost (Wiel and JEM, 2001).

Common energy labels disclose cost of operation of the system over a period of time, for instance over a period of one year, the energy efficiency of the system and general information of the system (Masjuki et al., 2000b). It has been done in some cases by showing the energy consumption or energy efficiency of the system on a scale when compared to other similar air-conditioning systems (Turiel, 1997).

By introducing an appropriate energy label, air conditioning systems with the best energy ratings and most competitive price, are more likely to have higher demands from the market. This has the effect of encouraging manufacturers to improve their systems whilst keeping their cost low to win a larger share of the market, and thus creates healthy competition among manufacturers.

In the energy labelling process, it is important that ranking of the air-conditioning systems, is reflective of the typical energy consumption during 'normal' use. This requirement on 'normal' use provides extra motivations for Brunei to initiate its own energy labelling process, as indeed, different geographical locations are subjected to different weather conditions and different races are acclimatized to different comfort temperature (Van-Straaten, 1967). Consequently, 'normal' use translates into different requirements under different local conditions. Test procedures for labelling purpose must also reflect the 'normal' use as defined by local conditions and local population.

As the main objective of energy labelling is to increase consumer awareness on the energy efficiencies of different air-conditioning systems, labels must be displayed prominently on the systems such that consumers may easily acquire the information to facilitate their decision-making process. Usually energy labels are attached to the front part of the indoor and outdoor unit of the split air-conditioning system as well as on their packaging (BNERI, 2015). This allows consumers visiting the retail outlets to view the displayed energy labels clearly and easily. Furthermore, it is common to see energy labels displayed on brochures, to make comparison even easier.

However, the increasing prevalence of the internet usage especially among the later generations, means that consumers may not even set foot on retail outlets and may instead fully rely on the internet to do their information gathering and purchasing (Elms et al., 2016). Whilst internet is an excellent source to find the best competitive price of the system, the information gathered on energy labels, which technically may come from anywhere globally,

may not satisfy the requirement of 'normal' use as defined by local conditions and local population. As such, Brunei may require to develop and operate websites on energy labels to make the local population who prefer the internet for their purchasing needs, be better informed in energy efficiencies of different systems.

In the future, barcodes and Quick Response Codes (QR codes) (Ramalho et al., 2018) may also be utilised for distributing information on different air-conditioning systems to consumers. These allow smart-phone users to compile and intelligently compare detailed information, including but not limited to information regarding its energy efficiency; empowering the consumers even more to make informed decisions.

Extensions of energy labelling for internet users as well as for use in barcodes and QR codes, are however beyond the scope of this paper.

There are two ways of implementing energy labels; mandatory or voluntary. By law, mandatory status obliges distributors or manufacturers to have and display energy labels for every air-conditioning systems that they distribute or manufacture. Policy-makers shall be responsible for providing the proper labels for the different appliances whilst manufacturers and distributors shall be responsible for the usage of the energy labels in a proper manner as specified by the policy-makers. Of course, mandatory energy label would also need to be enforced by the proper authority. This is in contrast to voluntary status which does not oblige the distributors or manufacturers, but rather encourages them to have and display energy labels for air-conditioning systems in their stock books (IEA, 2011; Shi, 2014).

As the main objective of energy labelling is to increase consumer awareness and allow them to compare between different systems, mandatory system is suggested for Brunei in order to make it more effective. This means that all air-conditioning systems irrespective of where it is manufactured, whether domestically or from foreign markets, are required to carry and display the proper energy label at the proper places. An authority must be assigned to enforce the energy labelling process and its compliance (BNERI, 2015).

3. Methodology

There are numerous models, types and brands of air conditioning system currently sold in the Brunei market. This is an important criteria for successful and effective development of energy labels as energy labels work most effectively when a spread of models' efficiencies exists in the market (Egan, 1998).

An important aspect of energy label development for air conditioning system is the ability to provide consumers with a method of comparing similar identical units of the systems with different brands, models, etc. It is critical that the energy label developed be suitable for the local populations; according to their socio-demographic characteristics, culture and preferences. As such, energy labels developed in another studies or used in another localities may not be simply adopted in a given country; despite the number of studies on energy labels (EGAT, 2006; Mahlia et al., 2002a) in the literature as well as the number of countries which have adopted different energy labels (Harrington and Brown, 2014; Harrington and Damnics, 2004). This paper addresses this issue; to develop energy label suitable to be implemented in Brunei whilst taking consideration of the local Brunei populations.

In this regard, three types of energy labels were developed for this study. Surveys were used to determine the most suitable energy labels from the three types of energy labels, based on consumers' responses and their level of understandings of the labels. Some individual consumer feedbacks were also considered in order to improve and finally, propose an energy label to be implemented in Brunei Darussalam. The methodology of energy labels development is discussed in the following section.

3.1. Energy labels development

Energy label must provide a method of comparing energy efficiencies of system to the consumers. Obviously, a common performance metric to measure the energy efficiency of air-conditioning system must be first established.

3.1.1. Labelling grading system for air-conditioning

The performance metric may be grouped or scaled, with defined efficiency categories or threshold to form a ranking system that shows the lowest and the highest energy consuming grades (for example, A, B and C or 1, 2 and 3 etc.). The idea is that it is much easier for consumers to remember and compare a simple ranking scale for a range of different air-conditioning systems than to remember specific performance metric values of a given system. Of course, the specific performance metric may also be given on the energy label; for consumers who want finer-grained information on the efficiency of the air-conditioning system.

The ratio of cooling output from an air conditioning system to the power input to the system may be used as the performance metric to compare the energy efficiency of an air-conditioning system. Generally, EER and COP of an air-conditioning system are evaluated by assuming an outside temperature of 95 °F and inside temperature of 80 °F with 50% relative humidity. However, evaluating efficiencies over a single operating condition fails to take into account the varying weather conditions expected at a given location and as such, cannot be said to be representatives of the system at that given location. Indeed, it is expected that the rainy season in Brunei would lower outside temperature and increase humidity, and thereby, reduces power and energy consumption, and conversely, the dry season would increase outside temperature and reduce humidity, and thereby, increases power and energy consumption. These interlace of weather conditions necessitate more accurate performance metrics that consider seasonal weather variations.

Recently, European standard EN 14825:2016 (Minetto et al., 2018; Standards) proposes seasonal performance indicators for this purpose; namely the Seasonal Coefficient of Performance (SCOP) and Seasonal Energy Efficiency Ratio (SEER). The calculations for SCOP and SEER are almost similar to COP and EER, respectively; however, evaluations of power and energy are made over a typical year's weather variations in a given location for SCOP and SEER (Standards) instead over a single operation condition only. Seasonal Coefficient of Performance (SCOP) with unit Watts per Watts (W/W) or Seasonal Energy Efficiency Ratio (SEER) with units British Thermal Unit/hour per Watts (Btu/hr/W) may be represented as:

$$\mathrm{SCOP(W/W)} = \frac{\mathrm{P_{output}(W)}}{\mathrm{P_{input}(W)}} \tag{1}$$

and

$$\mathrm{SEER(Btu/hr/W)} = \frac{\mathrm{E_{output}(Btu)}}{\mathrm{E_{input}(W.hr)}} \tag{2}$$

where

$\mathrm{P_{output}(W)}$: cooling output of an air-conditioning system in *Watts*

$\mathrm{E_{output}(Btu)}$: cooling output energy of an air-conditioning system in *Btu*

$\mathrm{P_{input}(W)}$: input power to the air-conditioning system in *Watts*

Table 1
Air-Conditioning Systems graded data with respect to SEER for system with cooling capacity less than 4.5 kW (ECM, 2016).

SEER	Letter grade	Number grade
9.00–9.48	G	1
9.49–9.97	F	2
9.98–10.46	E	3
10.47–10.95	D	4
10.96–11.49	C	5
11.45–11.93	B	6
≥11.94	A	7

Table 2
Air-conditioning systems graded data with respect to SEER for system with cooling capacity between 4.5 kW and 7.1 kW (ECM, 2016).

SEER	Letter grade	Number grade
7.50–8.03	G	1
8.04–8.56	F	2
8.57–9.10	E	3
9.11–9.63	D	4
9.64–10.17	C	5
10.18–10.70	B	6
≥10.71	A	7

E_{input}(W.hr) : input energy to the air-conditioning system in *Watts.hr*

The relationship between SCOP and SEER are given by:

$$\text{SCOP (W/W)} \approx \frac{\text{SEER(Btu/hr/W)}}{3.41214} \quad (3)$$

To be in conformance with the Association of Southeast Asian Nations (ASEAN), it has been suggested that Brunei should adopt SEER as its performance metric (BNERI, 2015). Furthermore, as a member of the British Commonwealth of Nations, the use of unit Btu is generally more understandable by the general population as a unit of cooling/heating in the Brunei context.

SEER may then be used to create grades of SEER; forming a scale that shows the lowest and the highest energy consuming grades. It is recommended to grade the labels into seven grades; thereby giving consumers a wider range of air-conditioning system grades to choose from as well as to avoid over-crowding of specific grades. The authors in reference (Mahlia et al., 2002a, 2001) reported that over-crowding of the higher grade in Thailand, with only five grades of efficiency, resulted in the air-conditioning system with the higher-grade rating to become less unique and thereby, reducing the effectiveness of the energy label.

Normally, the corresponding SEER within each grade is determined from the SEER of the air-conditioning systems that are already found in the country. In this respect, it is necessary to ascertain the range of SEER of the available air-conditioning systems sold in Brunei market in order to set an appropriate grades for the air-conditioning system with respect to SEER (Shi, 2015). This, however, is beyond the scope of this paper.

For the sake of examples, the highest and lowest SEER grades as adopted in Malaysia shall be assumed in our study (ECM, 2016). Malaysia differentiated air-conditioning systems based on its cooling capacity; cooling capacity less than 4.5 kW has lowest and highest SEER of 9.00 and 11.94 respectively whilst cooling capacity between 4.5 kW and 7.1 kW has lowest and highest SEER of 7.50 and 10.71 respectively. But instead of grading the air-conditioning system into 5 grades, air-conditioning systems shall be divided into 7 distinct grades according to Table 1 for air-conditioning system with cooling capacity less than 4.5 kW and Table 2 for air-conditioning system with cooling capacity between 4.5 kW and 7.1 kW.

Of course, these grades may be changed according to the actual SEER range of air-conditioning systems in the present Brunei market. In fact, it is normal practice to revise the grades of the air-conditioning systems with respect to SEER at regular intervals as shown in reference (EGAT, 2006).

The developed energy labels should enable the comparison of efficiency for similar systems that compete with types having similar dimensions and characteristics. In considering a purchase, consumers should be able to clearly see the price and energy labels of the systems and choose based on informed decisions.

There are different types of energy labels being adopted by different countries (Harrington and Brown, 2014; Harrington and Damnics, 2004) around the world. Two types of energy labels which have been widely used and shown to work effectively shall be used in our studies. First, the bar-type energy labels which were introduced in the European Union countries, Iran and Brazil and second, dial-type using star energy labels which have been used in Thailand, Australia, and India. The speedometer type of energy label shall also be used in this study, due to its popularity during the survey conducted in reference (Mahlia et al., 2002a).

Based on that, three types of labels were developed for this study. There are bar-type, dial-type with stars and the speedometer types. These labels have been modified in order to make it suitable to be used in Brunei. For each label presented, one version in the Malay language and another in the English language are given, with the intention of giving consumers the choice on which of the two languages to present the energy label in.

3.1.2. Label type A

The bar-type energy labels are by far, the most commonly used energy labels with 23 countries out of 44 countries covered in reference (Harrington and Brown, 2014) using this type of energy label. It originated from the European Union countries, but then was adopted by Iran, Brazil and many others. This label is chosen because it has been proven to be effective in the European Union countries and hence, its wide-spread use throughout the world. This label uses a series of colourful bars with a grading from the most efficient to the least efficient, with a bar next to the appropriate bar indicating the efficiency grade of the air-conditioning system. The developed energy label is presented in Fig. 2.

3.1.3. Label type B

This type of energy label originated from Australia, but then was adopted by Thailand. India has also chosen this label to introduce energy efficiency program for their household refrigerators. The differences between the Australian label and the Thailand label is that Thailand replaces the stars used in the Australian label by numbers. This label also works effectively in these countries and has been adopted by 9 countries out of 44 countries covered in reference (Harrington and Brown, 2014).

For the developed energy labels, both the star and number have been adopted similar to the ones adopted in India. The developed energy label is presented in Fig. 3.

3.1.4. Label type C

This energy label is a fusion of the labels type A and B above; it uses the grading A–G grades similar to energy label type A but uses the dial-type similar to energy label type B. Furthermore, it adopts the speedometer design which most Bruneians, being mostly car owners, can easily understand and relates to. Almost similar label is used in Korea. This energy label is proven to be very popular among Malaysians following the survey conducted in reference (Mahlia et al., 2002a). The energy label is presented in Fig. 4.

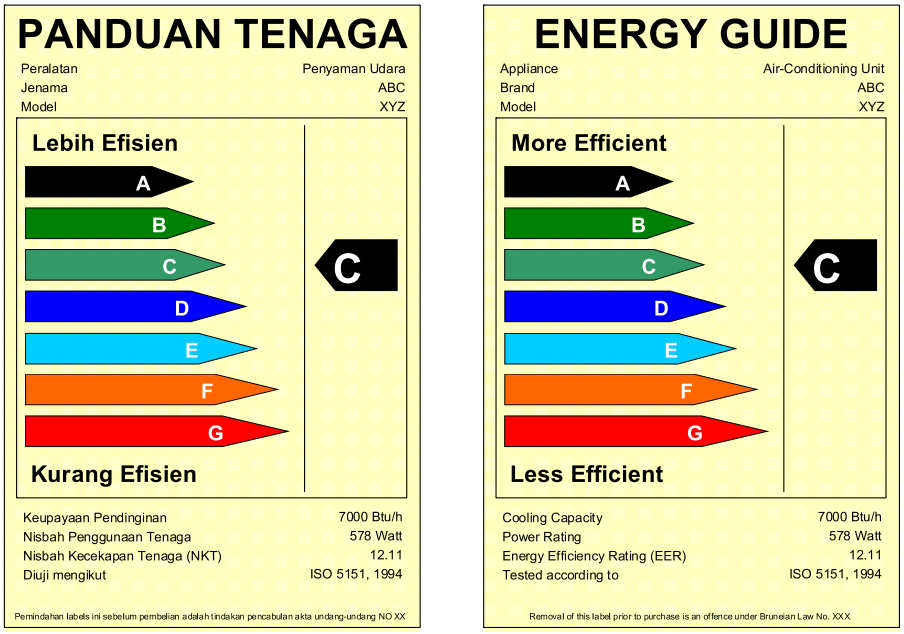

Fig. 2. Label type A in the Malay and English languages. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

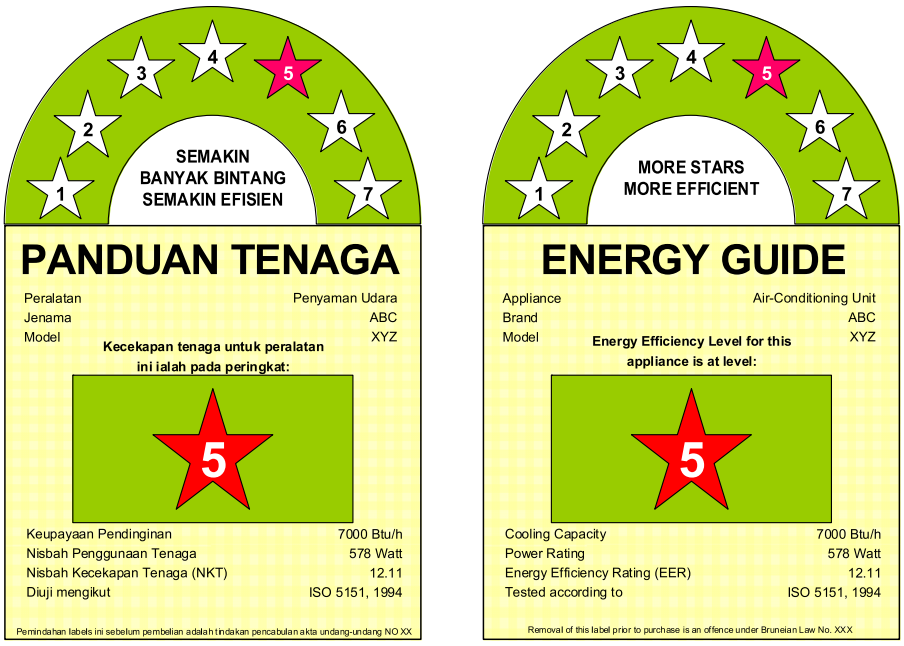

Fig. 3. Label type B in the Malay and English languages.

3.2. Data collection method

Energy labels must allow consumers to compare the energy efficiency of the air-conditioning system; and the information provided on the labels must be clear, must contain the right level of information and must be easily understandable. It is crucial that these three characteristics are satisfied in the local context, where the labels are to be adopted. As such, energy labels must be designed according to the local consumers' preferences and should be easily understandable.

The three different energy labels that have been chosen for this study are, from the authors' opinion, suitable to be implemented in Brunei. Anonymous online surveys are further conducted in order to choose the most suitable energy label from the three energy labels, to be adopted in Brunei.

Two types of data were collected from the survey; quantitative and qualitative data. Both types of data are used for label development. The quantitative data are required to select the suitable type of the label to be used Brunei whilst the qualitative data are used for improvement based on respondents input.

These data shall be obtained through online survey via survey requests in dual-language, targeting the general population i.e. the prospective consumers. The survey is conducted in dual-language; with Malay and English languages, which are the official national language of Brunei and the international language respectively.

Respondents are requested to state the language with which they prefer the energy label to be in. They are also shown the

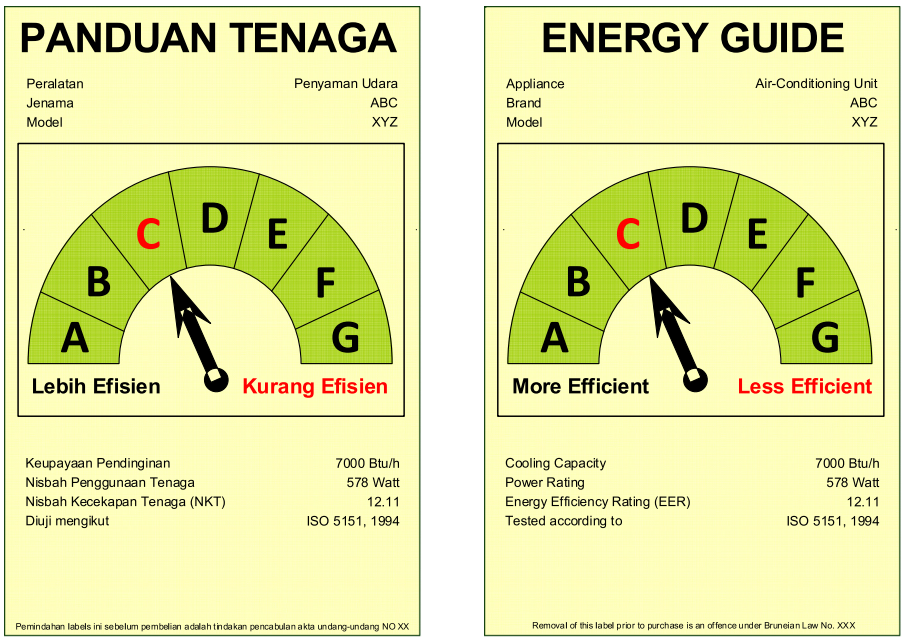

Fig. 4. Label type C in the Malay and English languages.

Table 3
Respondents' distribution according to sex.

Description	Male	Female	Total
Sample	187	175	362
Surveyed	(52%)	(48%)	(100%)
Population	216,600	200,600	417,200
Data	(52%)	(48%)	(100%)

three energy labels and asked a series of questions; among them to select an appropriate energy label that is easy to understand and proposed to be used in Brunei. The most popular energy label is then modified further according to the respondents input.

4. Results and discussion

The survey was kept online for a period of 7 days and a total of 362 respondents completed the survey. Results from the survey are presented as follow. The number and percentage of the respondents interviewed in this study are presented in Tables 3–7 and Figs. 5–9.

4.1. Respondent groups

Total respondents of 362 represents 0.087% of the total population of Brunei Darussalam (population of 417, 200 as of the year 2015 (DEPD, 2015). They are composed of 187 male and 175 female, corresponding to 52% and 48% of the total respondents respectively. Respondents' distribution according to sex is presented in Fig. 5.

The respondents came from all four districts within Brunei; with 277, 42, 39 and 4 respondents coming from the Brunei-Muara, Tutong, Belait and Temburong districts respectively. These represent percentages of 77%, 12%, 11% and 1% from the total respondents, for the four districts. Respondents' distribution according to districts presented in Fig. 6.

Out of the 362 respondents, 298 respondents or 82% identified themselves as Malay, 36 respondents or 10% as Chinese and 28 respondents or 8% as other races including other indigenous groups (Dusun, Iban, Melanau etc.) and foreign expatriates working in the

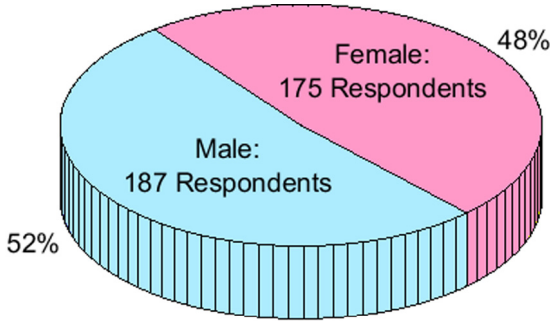

Fig. 5. Respondents' distribution according to sex.

Table 4
Respondents distribution according to districts.

Description	Brunei-Muara	Tutong	Belait	Temburong	Total
Sample	277	42	39	4	362
Surveyed	(76%)	(12%)	(11%)	(1%)	(100%)
Population	299,800	44,400	64,100	8,900	417,200
Data	(72%)	(11%)	(15%)	(2%)	(100%)

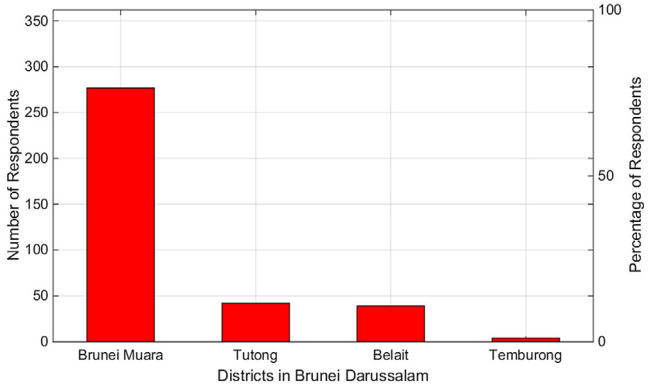

Fig. 6. Respondents' distribution according to districts.

Table 5
Respondents' distribution according to races.

Description	Malay	Chinese	Others	Total
Sample	298	36	28	362
Surveyed	(82%)	(10%)	(8%)	(100%)
Population	275,200	42,100	99,900	417,200
Data	(66%)	(10%)	(24%)	(100%)

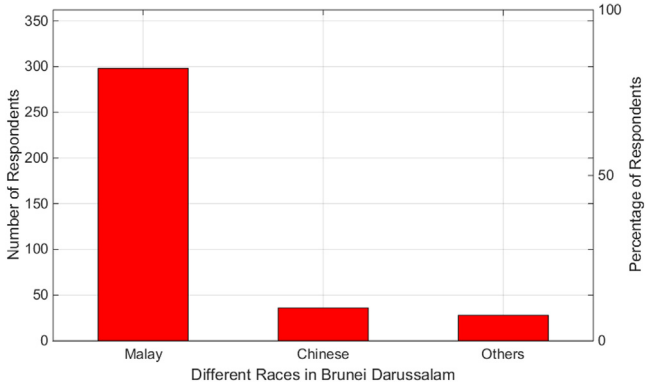

Fig. 7. Respondents distribution according to races.

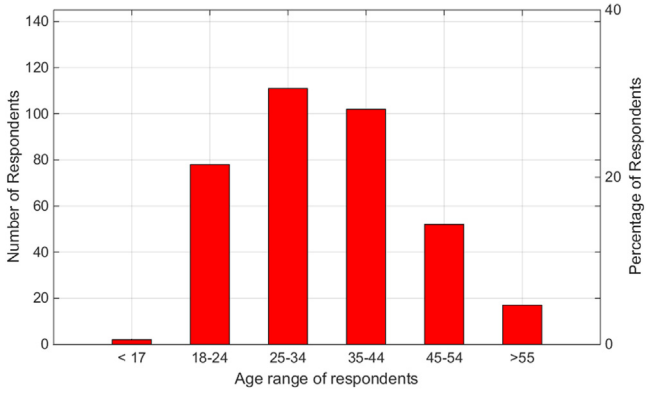

Fig. 8. Respondents distribution according to age groups.

country. Respondents Distribution according to Races is presented in Fig. 7.

In terms of age, 2 respondents (0.5% from the total) are below 17 years old, 78 respondents (21.5% from the total) are between 18 and 24 years old, 111 respondents (30.7% from the total) are between 25 and 34 years old, 102 respondents (28.2% from the total) are between 35 and 44 years old, 52 respondents (14.4% from the total) are between 45 and 54 years old and 17 respondents (4.7% from the total) are above 55 years old. Respondents' distribution according to age group is presented in Fig. 8.

The survey also groups respondents into different income group per calendar month; 81 respondents or 22.4% earn below BND$500 pcm, 31 respondents or 8.6% earn between BND$500–BND$999 pcm, 43 respondents or 11.9% earn between BND$1000–BND$1999 pcm, 63 respondents or 17.4% earn between BND$2000–BND$2999 pcm, 101 respondents or 26.9% earn between BND$3000–BND$4999 pcm and 43 respondents or 11.9% earn above BND$5000 pcm. Respondents Distribution according to Income Groups is presented in Fig. 9.

4.2. Labels selected by respondent based on frequency

Respondents were asked whether they prefer the label to be in the Malay language, which is the official national language of

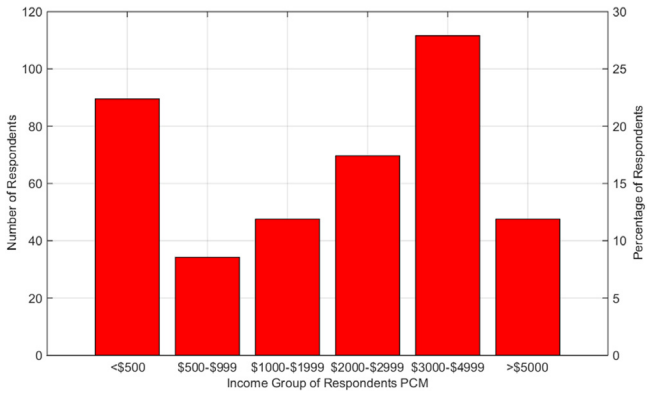

Fig. 9. Respondents' distribution according to income groups.

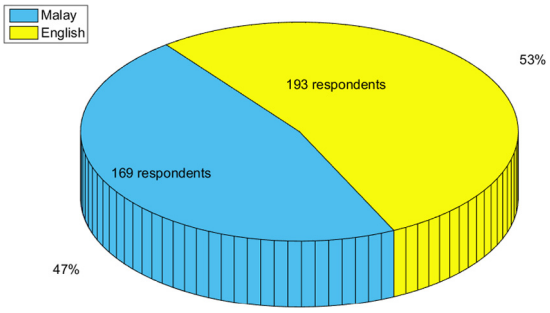

Fig. 10. Language preferences of respondents.

Brunei or in the English language, which is effectively Brunei's second language. 169 respondents out of the total of 362 respondents or 47% prefer the energy label to be in the Malay language whilst 193 respondents or 53% prefer the energy label to be in English language.

Among the 169 respondents who prefer the label to be in Malay, 76 respondents or 45% of the 169 respondents have selected label type C. Label type A and label type B were chosen by 34 and 59 respondents respectively, representing percentages of 20% and 35% respectively from the 169 respondents who preferred the label to be in Malay.

The most popular label type among the 193 respondents who prefer the label to be in English, is also label type C with 81 respondents or 42% of the 193 respondents. Label types A and B were chosen by 41 and 71 respondents respectively, representing percentages of 21% and 37% respectively.

Combining results from respondents who prefer the label to be in Malay and English, 157 respondents from the total 362 respondents chose label type C. This represents a percentage of 43 of the overall respondents. 75 respondents or 21% choose label type A whilst 130 respondents or 36% choose label type B.

It is clear from the survey that the order of preference (from the most preferable) for the language of the label and its label types are:-

(1) English version of label type C
(2) Malay version of label type C
(3) English version of label type B
(4) Malay version of label type B
(5) English version of label type A
(6) Malay version of label type A

The numbers of respondents and its related percentages are tabulated in Table 8 and Figs. 10–11.

Table 6
Respondents' distribution according to age group.

Description	Age group						Total
	<17 Yrs	18–24 Yrs	25–34 Yrs	35–44 Yrs	45–54 Yrs	>55 Yrs	
Sample	2	78	111	102	52	17	362
Surveyed	(0.5%)	(21.5%)	(30.7%)	(28.2%)	(14.4%)	(4.7%)	(100%)
Population	119,740	49,160	78,100	69,300	52,300	48,600	417,200
Data	(28.7%)	(11.8%)	(18.7%)	(16.6%)	(12.5%)	(11.6%)	(100%)

Table 7
Respondents' distribution according to income group.

Description	Income Group Per Calendar Month (PCM)						Total
	< $500	$500–$999	$1,000–$1,999	$2,000–$2,999	$3,000–$4,999	>$5,000	
Sample	81	31	43	63	101	43	362
Surveyed	(22.4%)	(8.6%)	(11.9%)	(17.4%)	(27.9%)	(11.9%)	(100%)

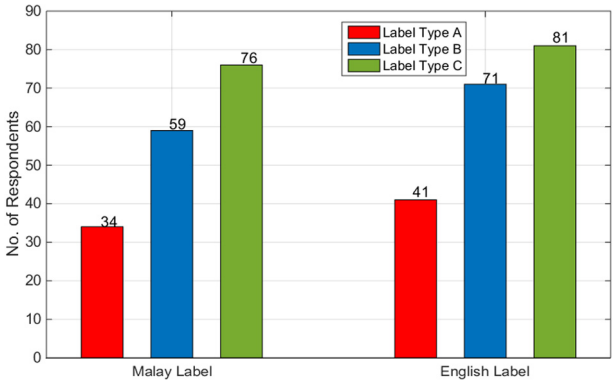

Fig. 11. Respondents' preference on label type.

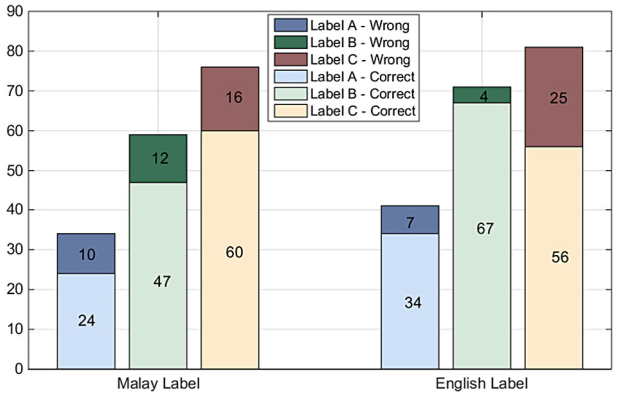

Fig. 12. Respondents' understanding on their preferred label type.

Table 8
Language preference of respondents.

Description		Energy labels			
		Label A	Label B	Label C	Total
Malay	Frequency	34	59	76	169
	% within Malay	20%	35%	45%	100%
English	Frequency	41	71	81	1931
	% within English	21%	37%	42%	00%
Total	Frequency	75	130	157	362
	% from total respondents	21%	36%	43%	100%

4.3. Labels selected based on respondent understanding

It is also necessary to ensure that respondents understand fully their selected labels. For this purpose, the respondents are given three different grades of energy label which they had selected earlier and are required to select the most efficient one out of the three grades of the same energy label. For instance, respondent that has selected energy label type A shall be further required to select the most efficient energy label from three different grades of energy label type A.

The study found that 288 out of the 362 respondents or 80% of the total respondents understood the labels which they had selected. Specifically for the English version of label type C which is the most preferred label, 56 respondents or 70% from the 81 respondents which preferred that label type, selected the most efficient grade for that label type correctly. For the Malay version of label type C, 60 respondents or 79% from the 76 respondents which preferred that label type, selected the most efficient grade for that label type correctly. This information is given in Table 9 and Fig. 12.

It is interesting to point out that combining the English and Malay version across the different label types, illustrate that the percentage of respondents selecting the wrong grades as the most efficient grades is higher for those who prefer label type C compared to those who prefer label type A or B. For label type C, 41 respondents or 26% of the respondents who preferred the label type made an incorrect choice as the most efficient grades. This is in contrast to respondents who preferred label type A and B with 23% and 12% respectively. This may suggest that although label type C is aesthetically pleasing to the eyes, some improvements need to be done to make it more understandable to the consumers.

4.4. Suggestions for improvement by respondents

The survey also requested suggestions from the respondents on possible improvements to the energy labels, in order to make it more effective and more understandable to the consumers. This is irrespective of the language the respondents chose, the label type they preferred and whether they correctly identified the most efficient label type.

However, from the 362 respondents who answered the online survey, only 96 suggestions which the authors deemed relevant and constructive to the topic are populated. Most of the respondents either did not suggest anything or gave suggestions irrelevant to the development of energy label for air-conditioning system.

Some suggestions are more specific and only relevant for the energy label type which the respondents had chosen, whilst some suggestions generally cover any label type. Only general suggestions and specific suggestions from the respondents who selected the most popular label type shall be considered. These suggestions are populated in Table 10 and shall be used to make improvements to the chosen energy label in the next section.

Table 9
Respondents' understanding on their preferred label type.

Description		Energy labels			
		Label A	Label B	Label C	Total
Malay	Frequency choosing label type	34	59	76	169
	Frequency choosing the correct efficient label type	24	47	60	131
	% within each group	71%	80%	79%	78%
English	Frequency choosing label type	41	71	81	193
	Frequency choosing the correct efficient label type	34	67	56	157
	% within each group	83%	94%	69%	81%
Total	Frequency choosing the label type	75	130	157	362
	Frequency choosing the correct efficient label type	58	114	116	288
	% within each label	77%	88%	74%	80%

Table 10
Constructive suggestions for label improvement.

Items	Suggestions
Language	□ Dual-Language i.e. Malay and English Languages
	□ Use Less Energy Usage/More Energy usage instead of more/less efficient and appropriate heading
Explanation	□ Give explanation of important parts of the energy label
	□ Advertise the label through website, televisions and roadshows to make consumer more aware
Colours	□ Brighten colours
	□ Ascend colours of grades (red to blue)
Information	□ Typical Electricity consumption and cost
Grade	□ Use number instead of letter for grading similar to car speedometer

The results of the study have shown that 193 respondents from the total 362 respondents prefer the energy label to be displayed in the English language compared to the Malay language. This represents a percentage of 53% from the total respondents; a 6% difference or a difference of 24 respondents from the total of 362 respondents. However, quite a number of suggestions from respondents indicate preference for dual-language energy label; similar to the implementation of energy label in Malaysia, Hong Kong, Algeria etc. (Harrington and Brown, 2014). This is expected, as although Malay language is the national language of Brunei, English language remains the medium of education in Brunei and widely spoken especially among the younger generations. Therefore, it is recommended that Brunei implement a dual-language energy label, both in Malay and English languages, in order to increase its effectiveness across all groups of the population.

By label type, label type C is preferred by 157 respondents or 43% of the total 362 respondents; with the Malay and English versions of label type C selected by 76 and 81 respondents respectively.

In terms of understanding of labels, it has been shown that for both the English and Malay versions of label type C, overall 116 respondents from those who prefer label type C understood the label. This corresponds to a percentage for 74% from the 157 respondents. However, looking at the relatively high percentage of respondents who did not understand label type C properly, label type C needs to be further modified according to the respondents' suggestions to make it works more effectively.

There are many suggestions from respondents for both Malay and English version of those three label types. This study considers general suggestions and suggestions specifically for the most popular energy label type, label type C; to make the label more effective and more understandable. The selected constructive suggestions from the respondents are tabulated in Table 10.

It is noted that although advertisement is technically not part of the energy label development process, many respondents have suggested it, highlighting the importance of advertising, especially before and during the early parts of the roll-out phase, in order to make the energy label more effective and understandable. Different parts of the energy label must be clearly explained during the advertisements and roadshows.

The improved energy label proposed to be used in Brunei is presented in Fig. 13. Remarks on the improved energy label are in order: -

(1) The grades are scaled from 1 to 7; with grade 1 representing air-conditioning system which is the least efficient and hence, "least saving" on electricity and grade 7 representing the most efficient system and hence, "most saving" on electricity.
(2) The gradual and ascending colour change from red to blue for the least efficient and most efficient system
(3) The arrow points to the grade of the current system, with its corresponding grade enlarged to highlight its grade.
(4) Monthly energy consumption and cost are preferable to annual energy consumption and cost, as it is common in the local context to measure electricity and electricity cost monthly instead of annually.
(5) The monthly energy consumption in kWh and its corresponding cost, are calculated based on the assumption that the air-conditioning system is operated 10 h daily with electricity charged at 8 cents per kWh, which is the nominal charge of electricity consumption per kWh for energy usage between 601–2000 kWh of electricity. The policy-makers need to decide on the normal condition of use in this case and the 10 h daily operation and corresponding monthly energy consumption/cost may be altered accordingly.

5. Conclusions

The main aim of energy label is to improve consumer awareness on the energy efficiency of the system and to facilitate comparison of the systems with others. It is envisaged that with the energy labels, consumers would be more inclined to purchase a more efficient air-conditioning system and at the same time, energy label encourages the manufacturers to improve the energy efficiency of their products. Collectively, these shall result in a considerable reduction in overall energy consumptions of the country; as air-conditioning systems represent the biggest chunks of energy consumption for residential and commercial buildings in Brunei.

As energy label concerns the consumers, it must be tailored to the preference of the local consumers whilst providing useful and understandable information. This study proposes a suitable energy label for air-conditioning system that may be adopted in Brunei Darussalam; based on consumer survey conducted on a sample of the population and includes constructive suggestions by respondents of the survey.

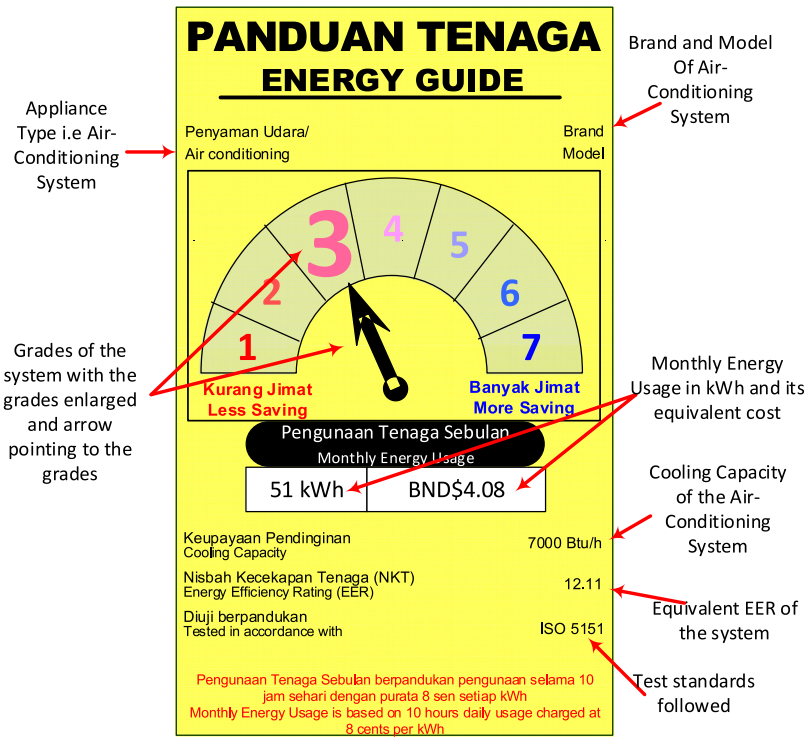

Fig. 13. Proposed energy label for air-conditioning system to be used in Brunei Darussalam.. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Although the proposed energy label is developed for air-conditioning system, it may also be used for labelling other systems (e.g. light bulb, motors etc.) with some modifications. The methodology used can also be adopted by other countries to develop their own energy labels; tailored to the preference and detailed of information for the local consumers.

In Brunei Darussalam, many sectors will get tremendous benefits in implementing the energy labels for this system; although consumers shall need to pay a relatively higher purchase prices for the system, it shall be compensated with lower electricity bill in the long term. Increasing efficiency of the system also indirectly reduces greenhouse gas emissions.

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